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AUTHOR Wyatt, Mollie L.  
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## ABSTRACT

Studies exploring the transition from early to middle adolescence have found a significant increase in formal-operational thinking, but it is questionable whether the typical adolescent is capable of consistently applying formal operational logic. To examine the relationship between Piagetian-based training techniques and formal-operational thinking, 55 education majors (19-22 years old) were tested using the Cognitive Exam, and then assigned to one of the four conditions (pretest, no pretest, proportionality scheme, or reality therapy). There were two training sessions for each group, consisting either of programmed tasks dealing with the proportionality scheme (representing the ability to understand the fact that the ratio of two quantities is equal to the ratio of two other quantities), or programmed reality therapy material. A percentage of the number of subjects functioning on the formal-operational level of cognitive development (characterized by a score of 70 to 93 points on the Cognitive Exam), showed that at the end of the pretest stage of the experiment, none of the subjects were functioning at the formal-operational level; at the end of the posttest stage, only one subject was functioning at the formal-operational level. There was no significant difference between the pretested and no pretest groups, and no significant differences between those receiving training and those not receiving training. A majority of the students were functioning between the concrete and formal levels of cognitive development. The large number of transitional formal thinkers indicates that individuals can function formally in one area and not in another, yielding more support for a continuity view of cognitive development rather than a stage view. (JAC)

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FORMAL-OPERATIONAL THINKING AND THE ROLE OF TRAINING

Mollie L. Wyatt  
Mississippi State University

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## FORMAL-OPERATIONAL THINKING AND THE ROLE OF TRAINING

The developmental process in individuals has been the object of study by many investigators influenced by the conceptual framework of Piaget and his colleagues. Most of the work has focused on the age span of birth to about 11; that is, on the sensorimotor, the preoperational, and the concrete operational stages in the developmental continuum. Comparatively little study has been done on the development of thinking in the stage of formal operations, the highest level of cognitive development.

Therefore, of particular interest to this study was the development of the fourth and final stage, that of formal-operational thinking. The formal stage is characterized by the ability to reason hypothetically. The individual in this stage is no longer confined to reasoning about empirical reality; reality is considered only a part of all that is possible. The person is able to imagine and reason about events that might never occur in reality, but which are theoretically possible. The thought system begins to work independently of its content and becomes an autonomous thinking instrument that can be applied to diverse data. The transition from concrete-operational thinking to that of formal thinking should occur around the age of 12 and continuing to the age of 15 according to Inhelder and Piaget (1958) is marked by the appearance of several new abilities unavailable at previous stages.

The preponderance of replication research in this area has been concerned with the proportionality and probability schemes. The determination of the development of an individual's understanding of proportions constitutes a critical test of formal-operational thinking. Results of replication research on proportionality consistently support this claim.

Studies exploring the transition from early to middle adolescence have indeed found a significant increase in formal-operational thinking. However, when percentages were reported there were usually 50% or less of the adolescents sampled functioning formally. Since Piaget has used a 75% criterion to indicate whether a particular group can be classified at a specific stage of cognitive development, it becomes questionable as to whether we can generalize that the typical adolescent is capable of consistently applying formal-operational logic. Therefore, the expectation that the adolescent and especially the college student uses formal-operational thinking is open to question.

Piaget (cited in Brainerd, 1978) admits that learning can influence the contents of each cognitive stage, but he places certain constraints on learning. These two constraints are: (a) The subjects to be trained must have already acquired the cognitive structures of the stage to which the to-be-trained content belongs, and (b) The procedures used to train contents must embody Piagetian laws of spontaneous cognitive development. The research on learning formal-operational contents is as yet scarce. However, the trend of

the findings is that we can teach formal-operational contents to individuals who have not yet acquired formal-operational structures. It also appears that formal-operational contents can be taught without resorting to active self-discovery training.

#### Purpose of Study

The purpose of this investigation was to ascertain the relationship between training techniques and formal-operational thinking of college students. Primary consideration was given to the subject's present stage of cognitive development, and the success or failure of Piagetian-based training techniques in advancing the present stage. Six hypotheses guided this inquiry:

1. Seventy-five percent of the subjects will not perform on a formal-operational level on the Cognitive Exam (Campbell and Tomlinson-Keasey, 1972).
2. There is no significant difference in mean posttest scores on the Cognitive Exam between the groups receiving Piagetian-based training and the groups receiving non-Piagetian-based training.
3. There is no significant difference in mean posttest scores between the groups receiving both the pretest and posttest and the groups receiving posttest only.
4. There is no significant interaction between testing and treatment.
5. There is no significant difference between mean posttest scores on the Cognitive Exam between the students functioning at the concrete-operational level on the pretest and the students functioning at the transitional formal-operational level on the pretest.
6. There is no significant interaction between training and level of cognitive functioning.

## METHOD

### Subjects

A sample of 55 male and female undergraduate students (19-22 years) enrolled in the College of Education were selected for this study. These subjects were chosen from a sample of 120 who originally volunteered. Those who were eliminated were either classified as graduate students or outside of the typical age range of an undergraduate student (19-22 years). Due to the restricted times of the subjects' availability, three different time periods were chosen for the study. Each subject was assigned a time and then randomly assigned to one of four conditions.

### Measuring Instrument

The Cognitive Exam developed by Tom Campbell and C. Tomlinson-Keasey, (1972) was utilized for both the pretest and posttest to measure the subjects present level of cognitive development. The Cognitive Exam consists of seven tasks. The seven cognitive tasks are as follows:

1. Metric Distance - subtest measuring the understanding of proportionality.
2. Chemicals - subtest measuring the propositional operation.
3. Flexibility of Rods - subtest measuring the understanding of propositional operations.
4. Ten Analogies - subtest measuring the subject's ability to transform abstract kinds of relationships.
5. Mice - subtest measuring the probability scheme.

6. Abstraction Task - subtest measuring the ability to do multiple kinds of transformations of information.

7. Coin Toss - subtest measuring the understanding of the probability scheme.

The Cognitive Exam was administered without a time limit. Directions stated that complete written explanations of how subjects determine each answer are more important than the answers themselves.

Scores on the Cognitive Exam were computed according to a scoring key which describes ranges of points which can be accumulated on each subtest. Based on these total points, three stages of cognitive development were identified:

(a) Formal-operational - 93 to 70 total points, (b) Transitional - 69 to 41 total points, and (c) Concrete - 40 to 5 total points.

#### Training Materials

There were two training sessions for each of the four groups. The training sessions were conducted for approximately 45 minutes on 2 days (Tuesday and Thursday). Materials used for each session were programmed materials such that students received immediate feedback on their performance. The programmed tasks were divided into two booklets using one in each session. The booklets used for the training procedure for the treatment groups consisted of six (three in each booklet) programmed tasks dealing strictly with the proportionality scheme. The proportionality scheme represents the ability to understand the fact that the ratio of two quantities is equal to the ratio of two other quantities. According to Inhelder and Piaget (1958) the proportionality scheme

is one of the most important schemes that must be acquired in order to function at the formal-operational level of cognitive thinking.

In order to make the groups as similar as possible, the non-treatment groups received programmed materials also. Reality therapy was chosen for these groups because it was assumed that the material would hold the subject's attention while at the same time be unrelated to the Cognitive Exam utilized in the study.

#### Procedure

Upon being randomly assigned to one of four conditions, each subject was assigned a time to report for participation in the study. Two rooms were utilized with two conditions running simultaneously in each room. As the experimenter was conducting conditions 1 and 2 (pretest groups), a female assistant was conducting conditions 3 and 4 (no pretest groups). All four conditions were run at each of the three time periods.

As subjects for conditions 1 and 2 arrived, they were told they would be given two booklets (Cognitive Exam and proportionality or reality therapy training). Subjects were then given the pretest and upon completion given the appropriate training booklet. The first session was concluded in approximately 1½ hours. The second session was conducted in the same manner. The only difference in procedure for session 2 was the subjects were given a

training booklet for their first task and then given a posttest for their second task. Again, the session was concluded in approximately 1½ hours.

As subjects for conditions 3 and 4 arrived, they were given the same instructions. However, since conditions 3 and 4 were the no pretest groups, only one booklet (proportionality or reality therapy training) was given during session 1. The first session was concluded in approximately 1 hour. The second session was conducted in precisely the same manner as session 2 for conditions 1 and 2.

#### Experimental Design and Data Analysis

The randomized Solomon four-group design was utilized to examine possible pretest sensitization and to examine other possible extraneous variation. This design actually amounts to doing the experiment twice. Consequently, if the results of the "two experiments" are consistent, greater confidence can be placed in the findings that would otherwise be possible (Kerlinger, 1966).

Two 2 x 2 factorial designs (Isaac and Michael, 1971) were utilized to investigate the problem. The unweighted means method was employed in the analysis of variance due to unequal cell n's. The independent variables were: (a) testing (pretest, no pretest); (b) treatment (proportionality or reality therapy); and (c) cognitive functioning (transitional formal or concrete). The dependent variable was scores attained on the Cognitive Exam. The difference between the 2 x 2 designs was the variables employed in the analysis of variance.

## RESULTS

A percentage was computed of the total number of subjects functioning on the formal-operational level of cognitive development. In order to be categorized as functioning on the formal level, subjects had to attain a total score of 70 to 93 points on Cognitive Exam. The results shows:

(a) At the end of the pretest stage of the experiment, no subjects were functioning at the formal-operational level, and (b) At the end of the posttest stage of the experiment, only one subject ( $n = 55$ ) was functioning at the formal-operational level (less than 1%).

Table 1 presents the analysis of variance data. The unweighted means method (Myers, 1979) was employed in the analysis due to unequal  $n$ 's in each cell.

TABLE 1

Analysis of Variance Summary Table for a 2 x 2 Factorial Design

| Source of Variation | <u>df</u> | <u>MS</u> | <u>F</u> |
|---------------------|-----------|-----------|----------|
| Testing (A)         | 1         | 12.43     | .88      |
| Treatment (B)       | 1         | 23.00     | 1.63     |
| A x B               | 1         | .12       | .01      |
| S/AB (adj)          | 51        | 14.01     |          |

An examination of Table 1 shows: (a) There was no significant difference between the pretested and no pretest groups, indicating there was no pretest-sensitization effects; (b) There was no significant difference between the groups

receiving training and those not receiving training; and (c) There was no significant interaction between the variables. To determine whether the unusually small value for the obtained  $F$  was due to the violation of assumptions underlying the analysis of variance, a procedure recommended by Myers (1979) was performed yielding an  $F$  (51.1) of 117.5 which was significant only at the .07 level. This is interrupted to indicate that no assumptions were violated.

Before the second analysis of variance was computed, subjects in the pretested groups were classified as concrete or transitional formal thinkers. The concrete thinkers were classified such if the pretest scores were less than 41. The transitional formal thinkers were classified such if the pretest scores were greater than 40.

Table 2 presents the analysis of variance data comparing both levels of functioning with the two levels of training.

TABLE 2

Analysis of Variance Summary Table for a 2 x 2 Factorial Design

| Source of Variation      | <u>df</u> | <u>MS</u> | <u>F</u> |
|--------------------------|-----------|-----------|----------|
| Level of Functioning (A) | 1         | 484.22    | 25.04*   |
| Treatment (B)            | 1         | 2.58      | .13      |
| A x B                    | 1         | 27.85     | 1.44     |
| S/AB (adj)               | 22        | 19.34     |          |

\* $p < .05$

An examination of Table 3 shows: (a) There was a

significant difference,  $F(1,22) = 25.04$ ,  $p < .05$ , between the Cognitive Exam scores of the concrete ( $N = 4$ ) and transitional formal ( $N = 19$ ) thinkers; (b) There was no significant difference in the two levels of training; and (c) There was no significant interaction between the variables, level of functioning and training.

Additional analysis of data showed that many college students are functioning on a transitional level of cognitive development. Transitional meaning that they are capable of understanding certain operations within the formal-operational level and at the same time not capable of understanding other operations thus causing them to remain on the concrete-operational level when total scores on the Cognitive Exam are considered. In other words, the transitional level is a middle of the road stage of cognitive development.

#### Discussion

The results of the present study reaffirm some previous findings related to cognitive functioning and develops a fuller picture of the different levels of cognitive thinking of college students. First, based on Piaget's theory (1951), adolescence marks the onset of formal-operational thinking; however, previous findings have not substantiated this age level for the onset of formal thinking (Arlin, 1975). The results of this study indicated that typical college-aged students (19-22 years) are not functioning in the formal-operational stage of cognitive development. Less than 1% of the sample were functioning at the formal-operational

level which was far below the 75% criterion used by Piaget (1951). Further inspection of the data showed that a majority of the sample were functioning between the concrete and formal-levels of cognitive development. This level was labeled the transitional stage indicating that college students possess some of the structures necessary for a higher level of thinking but simultaneously still employ operations that are distinctive of the concrete-operational level of cognitive development.

The two 2 x 2 analyses of variance for factorial designs yielded no significant effects between the variables (a) testing, (b) treatment, and (c) level of functioning. Significance was found,  $F(1,22) = 25.04$ ,  $p < .05$ , between the Cognitive Exam scores of the concrete and transitional formal thinkers. However, this significant difference was to be expected and cannot be attributed to treatment.

Possible explanations for the ineffectiveness of training are presented below:

1. The subjects did not possess the necessary structures for the formal-operational tasks when training took place, and training did not involve active self-discovery. Thus, the results seem to lend support to Inhelder and Piaget's view of learning.

2. Additional analysis of data revealed that training was effective in the sense of improving scores on proportionality tasks only and did not generalize to the other operations required on the Cognitive Exam. Consequently, little transfer of learning took place, and analysis on total scores was not significant.

3. Due to the fact that reality therapy training may have involved verbal reasoning, reality therapy training may not have been a successful placebo for the control groups, thus yielding no significant differences in the groups.

The results suggest that an alternate choice of training for the control groups, such as a psychomotor task, which would be completely unrelated to abstract abilities may have proven to be more effective.

Finally, additional analysis of data showed that generally all the subjects did well on the two subtests involving analogies. This finding is important because it has been observed in certain individuals that formal thought has been developed in one area but not in another (Lovell, 1971). This phenomenon is referred to as a decalage, or time lag. To explain the individual time lag, Lovell (1971) reasoned that familiarity with the content of a task and prior beliefs may facilitate or hinder the use of formal thought in the task solution. Thus, high scores on the analogies could be explained due to the fact that subjects for the present study were all in the College of Education and consequently, were more familiar with this type of task. Substantiation of Lovell's explanation (1971) also occurred in the present study in that many of the subjects were functioning on the transitional formal level, and thus are far from reasoning formally all the time.

### Conclusions

Based on the results of this study, the following conclusions were reached:

1. The percentage of subjects operating formally is well below Piaget's 75% criterion.
2. College students, majoring in education, tend to function on a transitional level between concrete operations and formal operations. The present study indicated that transitional thinkers performed on the formal level when

dealing with proportionality but remained on the concrete level of reasoning when dealing with probability and/or combinational thinking.

3. Training proved to not be significant, thus lending support to Inhelder and Piaget's view (1958) stating that subjects to be trained must have already acquired the cognitive structures of the stage to which the to-be-trained contents belong.

4. Familiarity with a task may facilitate the use of formal thought in the task solution.

5. The large number of transitional formal thinkers in the present study indicates that individuals can function formally in one area and not in another, thus yielding more support for a continuity view of cognitive development rather than a stage view of cognitive development.

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